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HUMAN FACTORS IN NETWORK CENTRIC WARFARE

By

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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The speed of information transfer in Network Centric Warfare is rapidly out pacing the human capability to absorb and act effectively. Numerc problems, such as micro-management and limited endurance have been documented in studies of human interactions in information systems. Mar these problems are the result of limited human cognitive capability in the face of the massive amounts of information provided in NCW. Specifica the operational level of warfare, commanders are being overwhelmed due to human factors, limitations, and tendencies.

With the gap between human capability and network capability widening, an obvious incompatibility between humans and machines is emergin This incompatibility will lead to problems in the future unless the military begins to implement solutions. The solutions proposed in this paper ran from simple filtering to computer based decision-making to the creation of a new warfare specialty.

Ultimately, the military must study the problems created by human – machine incompatibilities, develop effective solutions (vice workaround solutions) and implement the solutions quickly.

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Chance seldom interferes with the wise man; his greatest and highest interests have been, are, and will be, directed by reason throughout his whole life.

Epicurus, *Sovran Maxims*

Introduction

Those of us that grew up with only three channels to watch on a black and white television have seen amazing technological advances since the early seventies. As a child, I recall my father's purchase of a new device called a "calculator" that could add, subtract, multiply, and divide an eight-digit number. This machine was the size of a paperback novel and cost roughly $50.00 in 1973.

Thirty years later, the CD reader/writer on my Pentium IV computer is the size of a paperback novel and calculators are either in your watch or imbedded in powerful database software packages. In a few more years, I'd guess that young people that won't understand the term "paperback novel", or they will only have seen them sold as antiques at an on-line auction.

The information age has inundated us with access and information and as we never dreamed possible. It is only logical that we, as military members, embrace these new technologies to carry us to the next generation of warfighting. Can there be any doubt that the debates about the validity of Network Centric Warfare (NCW) are over? The concept has passed the viability test and we're now in the implementation phase. U.S. Navy ships are being retrofitted fitted with the IT-21 (Information Technology for the twenty-first century) system. The Multifunctional Information Distribution Systems (MIDS) is well on it way to bringing "legacy" platforms such as the F-16, FA-18, and Bradley Fighting Vehicle into the Link-16 world. The next generation command and control platform to replace the E-2C is

quickly rising in the Navy's priority list. In the near future, platforms that aren't part of the information link will not be invited to the next military conflict. Referring to Epicurus's words, the military can best avoid the harsh hand of chance through serious thought and preparation.

Network Centric Warfare is a concept of networked sensors and weapon systems. In this network, massive amounts of information are passed between network participants to allow all participants access to time, space, position, and identification (TSPI) data on friendly, hostile and neutral players. This nodeless network is aimed at giving all players in the battlespace as much information as required to conduct their individual missions. For the operational commander, NCW utility with regard to information warfare (IW) and command and control (C2) is tremendous. As stated by the Army Research Institute for the Behavioral and Social Sciences[1], NCW promises to:

- Improve tactical performance
- Overcome time and space restraints on collaborative efforts
- Increase the range and speed of access to information

One problem with the technology of NCW, as with so many blossoming technologies, is that the systems were developed and implemented without full consideration of the human factors, limitations, and tendencies that will dramatically effect the system's utility. Our military commanders will have to come to grips with their human limitations and tendencies before the power of NCW can be fully realized.

[1] Richard E. Christ, George E. Dodge and Harold W. Webb, *Impact of Information Technology on Battle Command: Lessons from Management Science and Business*. (Army Research Institute for the Behavioral and Social Sciences, February 1999), 2.

This paper will first discuss the human aspects on which we need to concentrate our search for solutions. Only after we understand the potential problems can we attempt to find solutions.

The second part of this paper will offer potential solutions. These solutions, taken as a whole or in parts, offer only a starting point. Additional thought and discussion will provide us the tools we need to deal with human limitations in NCW. As a point of embarkation, the solutions offered intentionally lack the granularity of a "plug and play" solution. Where applicable, details are included to increase understanding of the intent.

We now know more, but this makes one more, not less, uncertain.

Karl von Clausewitz, *Vom Krieg*

PART I – The Problem

In the approach to the issue of human factors, it is important to keep in mind that human factors are general and will apply to the majority of users. Like most 12 Step Programs purport, the first step is to admit you've got a problem. Military officers are generally not ready to admit anything that might be perceived as weakness - it is absolutely contrary to an officer's nature because they serve in a profession where strength is championed. The point here is not to show any human traits as a weakness, but rather, as an incompatibility with technology that must be overcome in the name of effectiveness. It is only after the realization that these tendencies can create difficulties that solutions can be proposed and implemented. The Army Research Institute for the Behavioral and Social Sciences succinctly states this: "the human dimensions of command are a critical constraint on the development of information technologies to support command".[2]

A deep discussion of the human problems in a network environment could occupy volumes. The appendix provides a scratch at the surface of the problems and provides supporting information for any readers who may not have personally observed the problems discussed. Briefly summarizing the appendix, the major problems that face NCW with regard to human tendencies are:

- **Micro-management** – the tendency for commanders to direct efforts at levels below their immediate subordinate commands
- **Picture Warfare** – the tendency to make the informational picture take precedence over the functions of subordinate commands or the tactical level

- **Information Overload** – a.k.a. Information Saturation, the inability of the human mind to absorb or act on all the information presented, especially in a networked information system

- **Collapsing Lines of Communication** – the ability and tendency of the commander to directly interface with tactical units, bypassing intermediate commanders

- **Poor Degradation** – the growing inability to function autonomously should the network be compromised in some manner

- **Endurance** – the limitations of humans to function continuously over long periods of time and the decreased efficiency of the human mind after long periods without rest.

This list of problems is not exhaustive. There are, without a doubt, numerous human factors and tendencies that have yet to be uncovered. As technology progresses, more problems with humans interfacing with machines will be discovered. The appendix is intended only to address those problems that appear most prevalent.

In researching the human factors influencing NCW, one related problem was uncovered. While the military in general is very good at documenting lessons from exercises and warfare, we are reluctant to reveal human shortfalls. In researching lessons learned from numerous military operations of the last ten years, no mention of human factors was made.[3] Lessons learned typically center on process shortfalls, and suggest only process improvements. Commanders and staffs must recognize that human factors are not individual

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[2] Ibid., Page3

[3] As indicated in the bibliography, sources of lessons learned include the CTC Quarterly Bulletins, studies of Operation Desert Strom by the Army Research Institute,and the Center for Army Lessons Learned (CALL) Special Edition for Somalia.

weaknesses. Only with this recognition will the lessons learned databases be of use in documenting human factor influences in NCW

If you understand others, you are smart.
If you understand yourself, you are illuminated.
If you overcome others, you are powerful.
If you overcome yourself, you have strength.

Lao Tzu, *Tao Te Ching*

PART II – The Solution

With the ideas of the preceding section in mind, now comes the job of offering solutions. The human limitations discussed address only one side of the problem. Clearly, problems may exist in the machines with which humans must interface in NCW. The proposed solutions address the human and machine elements of the problems.

The first lesson one learns at the U.S. Naval Test Pilot School is that if a task in an airplane is difficult, the pilot is not the cause – the design of the aircraft makes the task difficult. The pilot compensates for the poor design through training. This tenet is applicable in any system that involves human-machine interface (HMI). At the heart of the matter, there are only two avenues of approach to HMI shortfalls. In any human-machine system, there are only two pieces where any changes can be implemented – the human or the machine. Humans are "fixed" through training while machines are "fixed" through design improvement.

Typically, military training with regard to HMI consists of work-around solutions whereby the user compensates for system deficiencies. This is usually the cheapest and the most quickly implemented solution to system shortfalls and has become the catchall for deficient systems.[4] Although training provides the user with compensation tools, it should

[4] The author, based on two tours and six years experience as a test pilot working in the Navy's test and acquisition community makes this observation.

not be viewed as a total system solution. Because the system has two parts, the human and the machine, both parts must be examined to maximize the system's potential.

Likewise, a solution that addresses only the machines of NCW is probably not going to offer a full solution. Ideally, the solution set that addresses the problems of human factors in NCW will capitalize on the differing strengths of humans and machine, while reducing the negative effects of the differing weaknesses of humans and machines.

Logically, the tendencies and limitations discussed in Part I are really the symptoms of a problem. Discovery of the root problem that leads to the symptom is a matter of logically analyzing those factors that contribute to the process.

If NCW is in place to enhance the decision making process, then looking at the Boyd cycle is certainly appropriate. Analysis of the Boyd cycle of Observe – Orient – Decide – Act (O-O-D-A) will provide insight to logical solutions. The Boyd cycle is based on single decisions made in a continuing flow. In execution, the cycle is most effective when the phases of the cycle are balanced with respect to each other as shown in Figure 1.

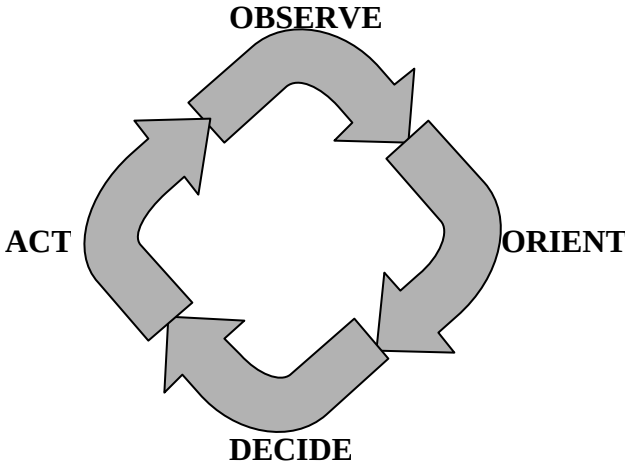

Figure 1
Boyd Cycle for Decision Making

When looking at NCW contributions to the Boyd cycle, it seems that the problems discussed in Part I come from skewing a single phase of the cycle. An information network feeds the input side of the Boyd cycle, specifically the Observe phase. The network machines are then used to enhance the Orient phase to allow the commander the best view of the situation. It follows, then, that in NCW, the Observe part of the cycle is grossly enlarged due to the increased flow of information.[5] The human half of the Boyd cycle, Decide – Act, is limited by the cognitive abilities of the human mind.[6] The human mind cannot process information as quickly as a network can present information, leading to an incompatibility. The perception of the cycle becomes unbalanced, as shown in Figure 2.

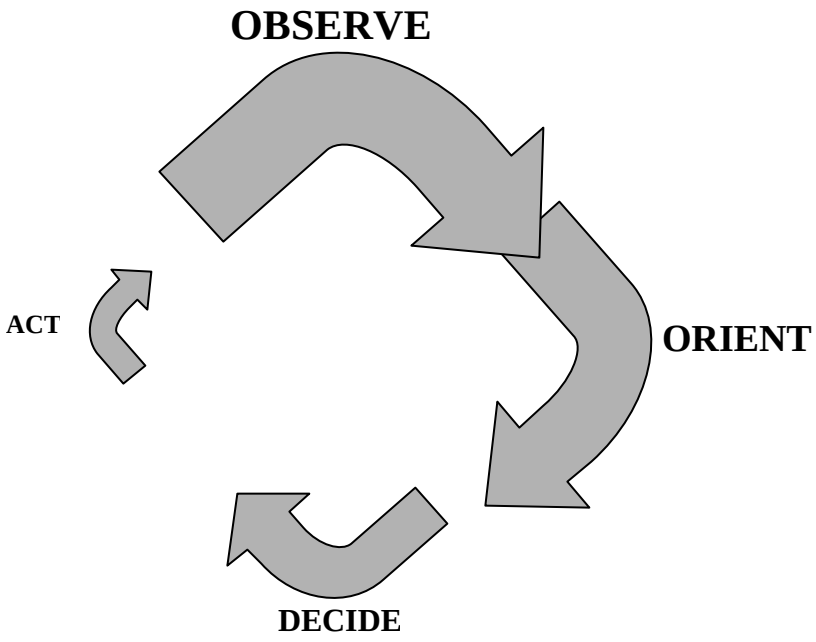

Figure 2
Skewed Boyd Cycle

[5] Chester F. Dymek, III, *Developing Situational Understanding: Will a Digitized Force See the 21st Century Forest through the Trees?* (School of Advanced Military Studies, United States Army Command and General Staff College, Fort Leavenworth, KS, 16 December 1998), 7.

In the case of micro-management, the commander tries to compensate for the imbalance by increasing his decisions and actions to a level commensurate with the information presented. This is also the case with collapsing lines of communication. The commander tries to increase his activity in the Decide – Act phase to keep up with network's ability to Observe – Orient. In the case of Picture Warfare, the commander is absorbed into building a perfect picture before he makes his decisions, perhaps in an attempt to allow himself more time to absorb the presented information.[7] Poor degradation capability results from the over-reliance on the bloated Observe – Orient side of the cycle. When the Observe – Orient side is subsequently and significantly reduced, the commander is seemingly left without the Observe – Orient phases altogether. The problem of endurance is unique in that it does not involve the decision-making cycle, and should not be held up against the Boyd cycle in this analysis.

Accompanying the skewed Boyd cycle is the notion that in NCW, warfare will happen faster. The notion is false, but will tend to further skew the commander's perception. While the information exchanges are happening faster, the war, specifically the tactical units, will move at the same speed with or without the network in place.[8] The result for the commander is the perception that he must keep up with the increased operational tempo by making faster decisions and increasing his actions.

The solutions, then, become a matter of restoring equilibrium to the Boyd cycle. Some problems may dictate reducing the Observe - Orient phases to a manageable level.

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[6] As an example of the differences between human speed and computer speed, one need only try to calculate a twenty column by twenty row spreadsheet, multiplying each entry by two. It becomes apparent that the computer is clearly faster than the human mind in performing even simple tasks.

[7] Susan S. Kirschenbaum, "Influence of Experience on Information-Gathering Strategies," *Journal of Applied Psychology*, Vol. 77, No. 3. (1992): 351.
Interestingly, this may be related to Dr. Kirschenbaum's observations of novice decision-makers.

[8] Efficiency, however, can increase dramatically in the NCW environment through collaborative efforts.

Some problems may dictate more efficient means of decision-making to enlarge the Decide – Act phases. Therefore, solutions fall into two categories: improve the design of the systems of NCW (technical) to better manage the enlargement of the Observe - Orient phases; and improve human capacity for using these systems (training) to enhance the Decide - Act phases. Technical solutions are aimed at easing the burden of the operational commander through various uses of existing technologies. Innovations will eventually fill the gap between humans and machine, but attempting to gauge the impact of these yet-to-be-invented systems is beyond the scope of this paper. Ultimately, training solutions are aimed at compensating for poor compatibility between NCW systems and the user. These solutions are presented in no order of preference or priority.

Machine Decision-makers

Starting with technological solutions, the single biggest change that will reduce the commander's burden is the use of technology to make routine decisions. Aside from the numerical methods applications, decision-making is truly at the heart of computer systems. By design, a computer can digest masses of information, compare that information to programmed decisions, and select the best course of action. Artificial intelligence promises to bring an aspect of creativity to automated decision-making that is currently lacking in NCW systems. Lt Col William McClure, USAF, provides an excellent discussion of the possibilities of a "machine commander" in his paper from the Air War College.[9] This concept is not only possible; it becomes plausible when considering reductions of military budgets and manpower. In order to keep tactical operators in the field, the military is faced

[9] William B. McClure, *Technology and Command: Implications for Military Operations in the Twenty-first Century*, (Occasional Paper No. 15, Center for Strategy and Technology, Air War College, Air University, Maxwell AFB, AL, July 2000).

with reducing its command level staffs. The opponents of this sort of approach immediately conjure up images from Stanley Kubrick's "Dr. Strangelove" where a "doomsday machine" automatically triggers nuclear weapons under specific conditions. While intended for satiric purposes, this "doomsday machine" is a plausible, albeit extreme example of the use of computer decision-making. Great care and study would necessarily precede and accompany such a step, and involvement at both the CINC and civilian leadership levels of the military would have to provide the guidance.[10] While this solution has the capacity to greatly reduce the burden on the warfare commander by enhancing the Decide - Act phases of the Boyd cycle, the initial reaction to machine decision-makers by the services will be resistance.[11] Overcoming cultural factors in all the services will be a major step in implementing this sort of solution.

Improved Information Presentations

A solution that concentrates on bringing the Observe - Orient phases more in line with human capacity grows from a study by the Air Force Institute of Technology. In this study, Capt Jerry Kain found a definite link between the information presentation format and accurate and timely decision making.[12] While this study concentrated on very basic information presentations (e.g. pie charts versus line charts) the lesson to be learned is that presentation can influence the Decide - Act phase. An example of a logical follow-on to Kain's work is to investigate possible relationships between information formats as they might be presented to the operational commander and the tactical background of the individual commanders. The design and acquisition cycles for military equipment already

[10] With this in mind, no attempt will be made to offer the range of decisions that could be made by computers.
[11] Dymek, 25.
[12] Jerry M. Kain, *The Effects of Psychological Type and Information presentation on Decision Making*, (Air Force Institute of Technology, Air University, Wright Patterson AFB, OH, December 1989).

involve the use of Design Advisory Groups (DAG), typically made up of the end users of system. Unfortunately, the benefits of a study such as Kain's are not integrated into the acquisition cycle or the DAG.[13] More eloquently said, "Experience has shown the devices that are designed according the 'design-then-train' philosophy forces users to adapt to the system. The user in entangled with the system terminology and jargons that are the designer's view of the world".[14] The heart of this solution is to first study the issue of information presentation, and then if the findings are conclusive, implement changes in information presentation formats. The International Journal of Human-Computer Studies published a report indicating that "cognitive load" could decreased simplifying information presentations through improved information integration and overlays.[15]

Clearly a strong link exists between an individual's ability to absorb information and the format in which the information is presented. Capitalizing on this link would increase the commander's ability to keep up with the enhanced Observe – Orient phases of the decision cycle in NCW.

Information Filtering and Clustering

Along with improving presentation formats, the value of the information must also be investigated. A major contributor to information overload is the unnecessary information that is available to the operational commander. By design, NCW offers all available information to all network participants. The operational commander, in concentrating on the operational picture, is forced to wade through all the available information to find the bits

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[13] This comment is based on observations by the author.
[14] Robert R. Hoffman, John W. Coffey, Kenneth M. Ford, Jeff Bradshaw, *Human-Centered Computing: Sounds Nice, But What is it?*
[15] Gregory J. Trafton, Susan S. Kirschenbaum, Ted L. Tsui, Robert T. Miyamoto, James A. Ballas, Paula D. Raymond, "Turning Pictures into Numbers: Extracting and Generating Information from Complex Visualizations," *International Journal of Human-Computer Studies*, no. 53 (2000): 847.

that truly contribute to operational situational awareness. At the tactical level, operators use variable filters based on range and lethality to reduce the information coming into the platform. Operational commanders cannot filter by range or lethality, and are currently forced to see all information in the network. The goal of the Common Relevant Operational Picture (CROP) is to reduce the picture to only the relevant information, but no standard or guidance was found for the CROP in the Joint Publications.[16] Extraneous information at the operational level would include, for example, weapon loads for individual aircraft. This sort of information, critical to the tactical commander, should be filtered for the operational commander, leaving a clear picture of only pertinent and relevant data. The goal of this solution is to minimize the effects of information overload, effectively paring down the Observe - Orient phases of the Boyd cycle to a level consistent with the operational commander's Decide – Act capacity.

One of the truly wondrous aspects of NCW is the ability to adapt the hardware. Although the hardware used is extremely complex, the concept of NCW is rather basic. Information is transmitted and received using a standardized format, or protocol. The received information is displayed to the user after decrypting and deciphering. Filtering information, then, is a matter of not processing incoming information, not displaying the information, and not cluttering the commander's attention with the information. Filtering seems a simple task, at least at the surface.

The most difficult part of constructing a useful filter to reduce the information thrown at the commander is in deciding what should or should not be filtered. The commander

[16] Specifically, Joint Pub 6-0, *Doctrine for Command, Control, Communications, and Computer (C4) Systems Support to Joint Operations*; Joint Pub 3-13, *Joint Doctrine for Information Operations*; and Joint Pub 3-13.1, Joint Doctrine for Command and Control Warfare (C2W), were reviewed.

should certainly be the major part of this decision, but each commander will have a different view of what detailed information is necessary.

In addition to filters, information clustering should be considered. Dr. Susan Kirschenbaum's study[17] suggests that correctly clustered information can enhance the decision-making process, particularly in expert decision-makers.

In practice, the solution will lie in a combination of information filtering and information clustering. Simply stated, reduce the information flow and package the remaining information better. Ultimately, the aim is to reduce the Observe -Orient size back to a manageable level.

Improved War Game and JTF Simulations

An area in which the military has typically excelled is in the use of modeling and simulation in a training environment. At the tactical level of warfare, the military provides simulations to better prepare tactical operators for combat situations that don't lend themselves easily to training. The military operates simulators and trainers for all warfare specialties – from aircraft simulators to ship simulators to live prototype reactors. The military easily sets the mark for training at the tactical level. Where the military fails is in the training of operational level commanders.

The goal of improved human performance in the face of information overload can be achieved partially by training the human element to filter information more efficiently. One of the bases for the formulation of the Navy Fighter Weapons School (Top Gun) was to train aircrew to better incorporate the new volume of information afforded from the use of airborne radar. The positive impact of Top Gun in this regard is evident in the improved air-to-air kill ratios during the Viet Nam conflict. Simulations have the potential to bring the

Boyd cycle back into equilibrium by bringing the human capacity to Decide and Act to a level equal to the bloated Observe – Orient caused by information overload.

Training operational commanders through simulation will better prepare them for the information flow of NCW. Simulations can be built as stand-alone systems for continuing staff training or built in conjunction with war game simulations for initial training of commanders and staffs. While building the commander's simulators is simple enough from a technical standpoint, getting the necessary people involved in the training will be challenging. It will require a concerted effort at the CINC level to get the right training for the right people. The creation of a syllabus to accompany the simulations would have to fall to a competent and credible source in the operational level of warfare.

Operational Warfare Specialty

This solution is a bit more radical than those offered so far, but Dr. Milan Vego provides an excellent basis for this solution in stating, "too many commanders in the past failed because they were unable or unwilling to raise their perspective above the tactical level".[18] He further states that "tactical excellence was not in the past, nor will it be in the future, a substitute for operational thinking".[19] Vego is right on the mark with these statements. The military spends millions of dollars and years of service to train officers in the arts of tactical warfare. When these officers have risen to the operational level of warfare, the vast majority of their dedicated training is at the tactical level. To assist operational commanders, the military provides a staff of officers who have also been trained to be tactical experts. Operational commanders' staffs currently have no expertise in the operational level warfare because as a military specialty, this level doesn't exist. Referring

[17] Kirschenbaum, *Influence of Experience*, 351.
[18] Milan Vego, *Operational Warfare*. (United States Naval War College, 2001), 569.

again to Vego, "Operational thinking is not an innate trait, but must be acquired by the systematic and untiring efforts throughout the career of the future operational commander."[20]

The solution, then, lies in creating experts at the operational level of warfare to assist the operational commander. Since none of the services currently field this warfare specialty, a new warfare specialty should be created. These specialists will be trained in tactical capabilities in all services, with a career pipeline that mandates only tours outside their service, in joint billets, or on operational level command staffs. The idea is to create watchstanders, similar to a tactical action officer (TAO) who can truly assist the operational commanders in bringing the Boyd cycle back into equilibrium. Just as Vego implies, training for these officers in operational warfare would start at commissioning. These officers would not have a tactical specialty or background.[21]

There are several advantages to this new warfare specialist. First, specialists would be well suited to pare down extraneous information, reducing the Observe – Orient side of the cycle. Second, without the burden of tactical expertise to tempt them, they would be able to clearly enhance the Decide – Act side of the Boyd cycle. Third, these watchstanders address the issue of human endurance in a continuous network by providing well-trained leaders in the operational "command by plan" world.

There are obviously tremendous cultural hurdles to be overcome to implement this solution. The most effective solutions are usually the most difficult to implement, especially when they require a major paradigm change. Many will consider the thought that an officer without tactical experience could effectively lead in an operational warfare environment

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[19] Ibid. 572.
[20] Ibid. 569.

absurd. Putting this into perspective: twenty years ago most naval officers would have cringed at the thought of being under the operational command of an Army Infantry General. Today, the CINCs enjoy full support from the services at all levels. In the quest for true "jointness", this should be viewed as step in the right direction.

[21] This is the main differentiation between Operational Warfare specialists and Joint Service Officer. JSO training starts upon selection to a staff or joint command and is generally done at the field grade or senior officer level. The Operational Warfare specialist would enter the service specifically for this designation.

PART III – Conclusions and Recommendations

The concerns discussed in Part I are not theoretical problems. Many readers have observed these problems first hand. The operational commander clearly faces challenges in the implementation of NCW and in realizing the full potential of this powerful tool. The multitude of studies pointing toward the problems is an obvious indicator that the military needs to take action very soon.

The recommendations to address the problems are simple. First, immediately begin detailed study to fully understand the incompatibilities between humans and the machines of NCW. In looking at the list of resources for this paper, it is clear that the Army has taken steps in this direction well ahead of the other services. The U.S. Army Research Institute, having shown significant interest in this realm, would make a logical lead agency in conducting these studies. The work done by the Naval Undersea Warfare Center indicates that the Navy has begun to take notice of the problems of HMI, and can provide valuable insight with the research they've already completed, as well as their current research. The Air Force Air University has conducted several studies that are applicable and should certainly be included in the leading research group. As with all new things in the military, our leadership must move these studies to the top of the priority lists and involve the operational level warfighters as part of the test group.

Second, implement imaginative solutions that address the problems directly. As stated, training is not a catchall solution because it only addresses half of the HMI system. Hardware improvements cannot be the only solution for the same reason. Unless we are truly content with a system designed by engineers unfamiliar with our needs, we must begin

solution implementation at the design level – both for the human (through training) and the machines (through improved designs).

Third, provide better guidance to warfare commander and staffs in the use of information. Specifically, our joint doctrine in this area falls short of the mark. The numerous Joint Publications[22] that address IW, provide vague guidance how to create information requirements lists[23], but provide no guidance on what should or should not be on this list. The adage that "you don't know what you don't know" applies here. Doctrine, because it is not a proscription, can certainly be expanded to provide real guidance for commanders and staffs in what they may not know.

Fourth, in support of continued improvement, commanders should seek out lessons learned with regard to HMI incompatibility and report them. This is the fastest means of bringing a problem to the forefront and can provide an excellent starting point for researching HMI problems. Lessons learned databases are the tools that allow us to learn from our failures and successes. If the tools aren't used, the opportunity to improve is impaired.

Finally, improvement needs to start now. NCW is not the future – it is the present and it is a step to whatever the future holds.

[22] Specifically, Joint Pub 6-0, *Doctrine for Command, Control, Communications, and Computer (C4) Systems Support to Joint Operations*; Joint Pub 3-13, *Joint Doctrine for Information Operations*; and Joint Pub 3-13.1, Joint Doctrine for Command and Control Warfare (C2W), were reviewed.
[23] These information lists are similar in nature to the Army CCIR, but intended for the joint commander.

Micro-management

The first human tendency to address is the desire to manage the things that are controllable and to control the things that can be seen. Major Jack Kammerer,[24] US Army, very appropriately says, **"**a pitfall in such systems is clear: commanders with a "perfect" battlefield view must exercise great care and discipline not to intervene in their subordinates' activities". He further says, "digitization makes it more imperative that the commander continue to discipline himself at all costs from routine electronic intervention". The tendency is, in a word, micro-management. This problem is becoming more and more apparent as commanders are given masses of information in near real-time concerning the disposition of subordinate commands. Because their expertise is typically at the tactical level, commanders are inclined to attempt control of the tactical picture. Micro-management is dangerous for at least three reasons. First, micro-management tends to negate the authority of intermediate level commanders. Second, the desire to focus on the tactical picture necessarily removes the commander's attention from the operational level of command. Third, the commander is not as well versed in the latest tactical training, techniques, and procedures as the tactical operators. The human tendency to micromanage is the single most common problem found throughout the research for this paper. Dr. Milan Vego accurately says "the commander's freedom of action at the operational level is greatly enhanced through decentralized decision-making, based on a clear statement of his intent and his use of task-oriented orders".[25] Given Vego's view, the military must recognize the gravity of this problem in dealing with NCW.

[24] Jack Kammerer, "Preserving Mission-Focused Command and Control," *Military Review*, Sep/Oct 1997. Internet Source
[25] Vego, 579.

Picture Warfare

Just as the name implies, NCW is about creating a central network of information. The subsequent dissemination and display of this information creates the heart of NCW. One of the most outspoken proponents of NCW, ADM Arthur Cebrowski, stated in an interview that "the war becomes more about the chase than the kill; the most important asset on the battlefield is not a weapon but a sensor".[26] The sensor, at very least, is the most important asset in the network, but unless the operational commanders maintain the ability to inflict military strength, the supporting network is useless for military purposes. A network of information that exists for its own sake is militarily useless. The popular phrase "Knowledge is Power" is both applicable and bothersome here. Knowledge alone does not equate to power. It is the correct application of knowledge that creates power. A network that exists to support other military aims is invaluable. Unfortunately, ADM Cebrowski is not stating a new notion. The months following Operation Desert Fox in Iraq in late 1998 present an example of the danger of this thinking. All U.S. military aircraft flying in support of Operation Southern Watch were required by the JTF commander to transmit IFF modes 1, 2, and 4 to ensure that the Combined Air Operations Command (CAOC) had the most accurate picture of friendly forces in the "no-fly" zone. The problem was that these IFF modes were routinely tracked by Iraqi system. The commander, with this knowledge, decided that his picture of the airspace was more important than the increase in vulnerability of the tactical units. While acknowledging the commander's prerogative to make these decisions, it must be realized that emphasizing the picture, or the network, for the sake of any individual's situational awareness can and will unnecessarily provide vulnerability to the forces we're working against. This should not diminish the potential that NCW brings to the

operational commander. It must be recognized that an information network is a tool for effective warfare, not a military end. As such, the use of the tool must be in concert with the commander's aims.

Information Overload

The potential occurrence of information overload increases dramatically in networked information systems. While this problem is recognized throughout militaries, the business world and academia, a universal definition of the problem is surprisingly elusive. Major John Sutherland[27] defines the problem as "having to make a decision within a timeframe that is too short to process all the information effectively in the face of an undifferentiated flow of information". Accepting this as a suitable definition of the problem, NCW provides the key elements of information overload: compressed timeframe and undifferentiated flow of massive amounts of information.

Information Overload is well documented throughout the world of information technologies. With so much information available to the operational commander, it is difficult to mentally filter the useful and pertinent information from the bulk of information he can access. A military think tank in the Netherlands studied information overload and found that information overload leads delayed decision making and, to a lesser extent, led to incorrect decisions or no decision at all.[28]

The results of information overload are varied and depend largely on the individual making decisions. Dr. Susan Kirschenbaum, a psychologist at the Naval Undersea Warfare

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[26] Bill Keller, "The Fighting Next Time," New York Times, 10 March 2002. Bill Keller. Final, sec. 6, p. 3.
[27] John R. Sutherland III, *Win, Lose or Draw; CCIR and the Commander's Role in Building Shared Vision*, (School of Advanced Military Studies, United States Army Command and General Staff College, Fort Leavenworth, Kansas, 16 December 1998), 18.
[28] R. van der Kleij, H.J. Griffioen-Young, H.A.M. Luiijf, M.H.A. Klaver, *Information Operations: Threats to the effective use of information in command and control*, (TNO Human Factors Research Institute,. 21 June 1999). 8, TNO Report TM-99-A049.

Center, during an interview with the author, described at three possible decision outcomes of information overload. The outcomes discussed were delayed decisions, decisions made by "anchor and adjust" model[29]; and decisions based on hypothesis justification[30].

Collapsing Lines of Communication

Using the example of Desert Fox again, a new problem has emerges that is a direct result of NCW. The lines of communication, from a tactical standpoint, are difficult to discern. Tactical Command and Control platforms are becoming little more than relays to extend the communication range of the operational commander. With the entire picture of the battlespace on a computer driven display, the commander is constantly tempted to revert to a "command by direction" vice "command by intent" or "command by plan"[31]. As our military training generally dictates, the commander is proactive, which results in the commander talking directly to the individual aircraft. This can only create confusion in the minds of the tactical operators as to the chain of command. The commander is acting well within the prerogative of his authority, generally without realizing the confusion he may have caused.

The ease with which a commander can access and control the actions of subordinates through an information system has been thoroughly addressed in several studies conducted by The Netherlands Organization (TNO) for Applied Scientific Research.[32] This organization clearly establishes a link between the problem of collapsing communications

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[29] This decision-making mechanism occurs when the subject makes an assessment based on limited or initial information (anchoring). Subsequent information is used by the subject to adjust the initial assessment vice making a new assessment (adjusting).
[30] This decision model when the subject has a preconceived assessment and uses information presentations to uphold the assessment.
[31] McClure, 3.
[32] van der Kleij, Griffioen-Young, Luiijf, Klaver, 11.

and micro-management. Specifically, the expanded lines of communication in an information system lend themselves to micro-management.

Poor degradation capability

Increasing use of technology tends to breed dependence on technology. An example of this concept the automobile. Most Americans consider the automobile a necessity, yet the first half of America's history was written without the automobile. A military example is the use of radar in fighter aircraft. It was seen during the early implementation of radar that many pilots, especially the younger pilots, were losing the perishable skills of dog fighting. This was attributed to the emphasis on radar missiles and the proposition that dog fighting was no longer tactically necessary. During the Viet Nam conflict that proposition proved false, and he trend of decreasing kill ratios forced the resumption of training pilots in dog fighting and the creation of the Navy Fighter Weapons School (Top Gun).

The problem is that we tend to become reliant on technology to the point that we can't function without it. When NCW is fully implemented and the operational commander is completely "on line", what will happen when someone trips over the power cord?

Joint Pub 6-0, 3-13, and 3-13.1 all provide solid guidance for the setup of C2[33] and C4[34] systems to support Information Warfare (IW). They do not provide guidance for regression if assets are not available, fail, or are neutralized through combat action.

Endurance

A well-known problem of warfare is human endurance. Automated networks are able to operate continuously while the human commander can only operate in intervals. Even

[33] Command and Control
[34] Command, Control, Communications, and Computer Systems.

removing the obvious needs for rest and sustenance, the human mind is not able to remain constantly focused without decreased capacity for effective decision making.

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